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The use of PLASTIC TUBING for Collecting and Transporting MAPLE SAP

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ABSTRACT

The use of plastic tubing provides an economical, labor-saving method for collecting maple sap. Instructions are given for the installing, disassembling, cleaning, storing, and reinstalling of plastic tubing.

This is a report of work done, with the cooperation of the Maple Sirup Industry, at the

EASTERN UTILIZATION RESEARCH AND DEVELOPMENT DIVISION

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THE USE OF PLASTIC TUBING
FOR COLLECTING AND TRANSPORTING MAPLE SAP

METAL PIPE LINES

The use of pipe lines in the maple sugar bush to transport maple sap is not new. The most frequent type of installation was that of a metal pipe to run sap from one part of the sugar bush to another, especially over impassable terrain or from a storage tank, at the edge of the sugar bush, to the evaporator house. The use of metal pipe lines requires careful layout with numerous supports as shown in Figure 1. All of these rigid lines, whether iron pipe, sheet metal, or wooden troughs, had one pronounced and serious fault. They had to be installed with great care and at considerable cost, so that there would be a continuous pitch from one end to the other with no sags. Sags, in the case of metal pipes, were areas where sap would lodge and on freezing would cause the pipe to burst. In the case of the open troughs these sags resulted in loss of sap from overflow. An even greater drawback, now that the need for sanitation in sap handling is realized, is that these pipes or trough lines are very difficult to clean and sanitize. Nevertheless, the savings they effected in time and labor in sap harvesting often more than offset their disadvantages.

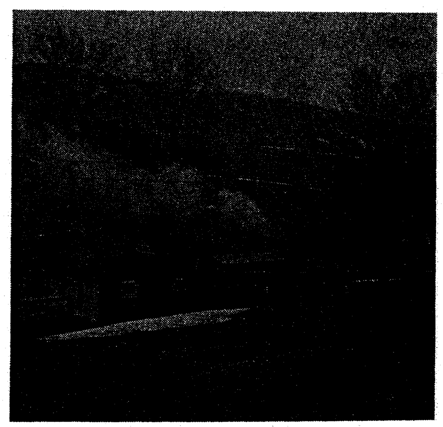

Figure 1. Metal pipes require careful layout with many supports.

ADVANTAGES OF PLASTIC TUBING

With the advent of plastic tubing most of the objections listed above were overcome. The cost, flexibility, elasticity, and ease of maintaining plastic tubing clean and sanitary has accounted for its wide acceptance by producers throughout the entire maple area. The acceptance of plastic as a means for collecting and transporting maple sap in the sugar bush is a major breakthrough in the modernization of the 300-year-old maple industry to put its production on a par with other farm products.

The use of plastic tubing has practically eliminated the hard, unattractive labor of collecting sap that had to be performed under adverse weather and ground conditions. It has also eliminated as much as 40 percent of the cost of sirup making. No longer is it necessary to construct expensive roadways through the woods to support heavy tanks of sap, nor to open these roads for the maple season following heavy snows. Tapping need not be delayed until the sap season has arrived. Large crews do not have to be hurriedly assembled to tap and hang the buckets. Instead, the light-weight plastic tubing can be carried by hand through the woods, whether snow-covered or not. Through the use of germicidal taphole pellets the trees can be tapped and the tubing installed at any convenient time prior to the sap season. The use of sanitary practices and the germicidal pellets prevents premature "drying" of the taphole.

EARLIER EXPERIENCES WITH PLASTIC TUBING

Some setbacks were encountered when plastic tubing was first introduced. Since it had been over-emphasized that sap issues from the tree under high pressure (2), systems adopted for the installation of the pipe lines were patterned after those used for high-pressure water lines. It was anticipated that the pressures developed by the tree were sufficient to force the sap through the pipe lines. Such was not entirely the case. The sap leaks (runs) from the tissues of the tree under a wide range of pressures, from very low (almost immeasurable) to a high of 30-40 p.s.i. (pounds per square inch). The amount of this pressure is governed by many factors, among which are the temperatures of the air, tree bark, and soil. In many runs, and often throughout most of a given run, the sap oozes from the tree under very low tree pressures. Thus, only a slight obstruction in a pipe or tube line will provide sufficient back pressure (resistance to flow) to equal or exceed the pressure at which the sap is being exuded from the tree. Hence, sap flow is retarded or prevented.

Back Pressure

Causes for back pressures (obstructions) in the line are (a) gas (vapor) locks resulting from pockets of gas exuded from the tree along with the sap (4), or from air pockets that result from air that has leaked into the tubing around the different connections, (seldom are these joints gas tight), (b) low places in the lines where pockets of sap collect, and (c) ice plugs of frozen sap. Of these, the gas locks are most frequently encountered and may cause a back pressure sufficient to support a 5-foot column of sap. However, these can be kept to a minimum by careful installation.

Frozen Lines

The effect of ice in the pipe lines is a controversial subject. Many believe that by the time the air temperatures have raised sufficiently to cause sap to ooze from the tree, the tubing will have warmed sufficiently to partly melt the ice and allow passage of the sap. Others believe that the elasticity of the tubing is adequate for sap to pass by the ice plug. This is unlikely. Still others believe that tubing laid directly on the ground, whether snow-covered or not, will absorb enough latent heat from the earth to melt the ice in the tubing before any appreciable flow of sap occurs. It is not uncommon to have the ice in tubing installed on the ground melt before the ice in tubing suspended in the air. (This can be observed when the two systems of installation are in the same sugar bush.) There is almost complete agreement that ice in tubing layered between two falls of snow melts very slowly due to the insulating effect of the snow. This tubing must be pulled up out of the snow before the ice will melt and unblock the lines.

Pitch of Lines

Since maple sap is not exuded under high pressure from trees at all times, the best method for installing the tubing is one patterned after that used in gravity-flow waste-disposal systems with the main or trunk lines being of sufficient diameter so that they are never overloaded. These systems are installed wherever possible with a continuous, even though slight, pitch of both the feeder lines (laterals) and trunk (main) lines toward the exit end. Also, following the pattern of waste systems, vents must be installed at all high points to prevent gas locks. However, lines will function satisfactorily on level ground if correctly installed. See "Lateral Lines."

One of the outstanding features of the plastic pipe-line arrangement is the "closed" system which minimizes microbial infections and keeps the sap clean and free of foreign matter. However, infection can and does occur; therefore sanitary precautions must be observed in the installation and maintenance of the system. The immediate effects of infection are deterioration and spoilage of the sap. Since infection can be translocated by the moving sap, two or more tapholes must not be connected in series. This would favor the spread of infection from one taphole to another (1) and would result in premature stoppage of sap flow. For the same reason the taphole must be of sufficient height so that during periods of rapid sap flow the top of the sap that rises or stands in the drop line will be at least 5 inches below the taphole.

The installation of flexible plastic tubing (laterals or mains) suspended in the air above the ground, free of sags between points of support and with a continuous pitch, becomes an even greater problem than with rigid iron pipe. This would require a suspension cable stretched from tree to tree above the tubing. The tubing would be held in a "straight" course by means of different lengths of hangers attached to the cable. In practice, however, due to expansion and contraction of the tubing and cable caused by fluctuation in air temperature and because of the non-rigidity of the tubing between the hangers, sags cannot be prevented from forming. Likewise, to locate these laterals and mains so that all tapholes will be a small but fixed distance above the mains (3) would add materially to the problems of installation requiring numerous main lines and short lengths of laterals. Such a system would be ideal for small installations involving only a few trees. In expanding this to a large operation the costs of initial installation, take-down, and reassembly might be excessive.

INSTALLATION OF TUBING

A method for installation of plastic tubing which eliminates most of the faults listed above has been developed. It provides a simple, inexpensive, and satisfactory method for installing, taking down, washing, sanitizing, and reinstalling plastic tubing. This is based upon several years of trial-and-error methods of installation of tubing, and upon consultation with numerous maple producers and equipment manufacturers. The method is economical of materials and labor, minimizes spread of microbial infection, and tends to eliminate gas locks and other obstructions that would cause build-up of back pressures in the lines.

Equipment

Tubing:

Drop Lines. The drop lines are complete assemblies consisting of a vent tube, spout, 3- to 5-foot lengths of 5/16-inch tubing and a plastic tee.

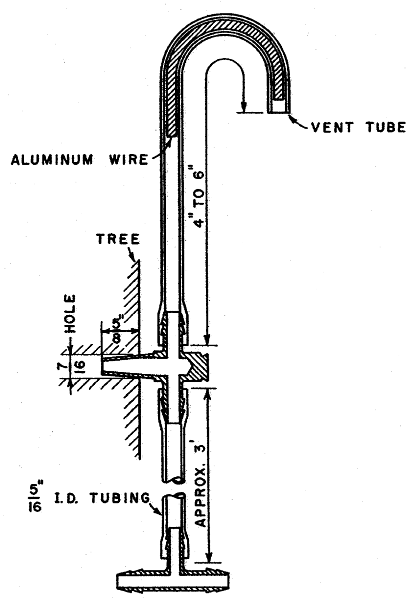

Figure 2. Vent tube for drop-line assembly.

Vent Tubes for Drop Lines. These U-shaped 7/16-inch I.D. tubes formed with a short piece of wire are 4- to 6-inches long and are attached to the vent tubulation of the spout. (See Figure 2). The U-shape tends to prevent access of microorganisms into the system.

Lateral Lines. 5/16-inch I. D. tubing. These are lines laid on the ground and connect the drop lines to the main lines.

Main Lines. The size of these will vary from 1/2-inch to 1-1/2-inches I. D.

Vent Tubes for Main Lines. These are 5/16-inch I. D. tubes, 8- to 10-feet long.

Spouts:

The spouts have two tubulations, one for the sap discharge and the other for venting gases.

Tees and Connectors:

Plastic tees, connectors, and other fittings of appropriate sizes are required for connecting drop, lateral, and main lines.

Hypochlorite Solution:

One gallon of a commercial bleach to 19 gallons of water. The bleach must not contain a detergent.

Sanitizing Pellets:

One compressed germicidal pellet is required for each taphole.

Assembly and Layout of Tubing

The drop lines are completely assembled at odd hours prior to the sap flow season and before installing in the sugar bush. A complete drop line is used for each taphole irrespective of whether there is one or more per tree. Figure 2 illustrates a drop-line assembly.

In order that the tubing laterals and mains are installed in an orderly fashion and that advantage is taken of any natural pitch, the route the laterals and mains are to follow in the sugar bush is laid out and the trees along the route are blazed. The painting of the tree with vertical lines showing the number of tapholes to be made per tree will serve as blaze marks and the paint can be applied in a fine stream from a pressure paint can. A narrow stripe can be painted by holding the nozzle of the paint can close to the tree.

Tapping and Installation of Drop Lines

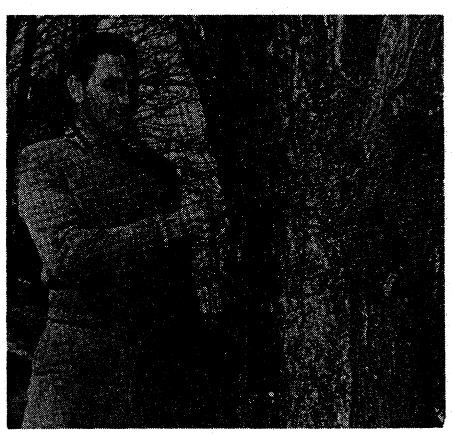

Figure 3. Sanitization of the taphole with hypochlorite solution improves sap quality and maintains sap flow.

Well in advance of the sap flow season the trees are tapped and the drop lines are installed by two three-man teams.

The first man of team number one locates the position for the taphole and bores the hole. He sanitizes the bored hole by syringing it with the hypochlorite solution and by inserting a sanitizing pellet, as shown in Figure 3.

The tapholes in trees on

slopes should be at least 3 feet above the ground and tapholes in trees on level ground must be at least 6 feet above the ground. The latter height is to provide the hydrostatic pressure required to move the sap through the lateral lines.

The length of the drop lines is determined by the height of the taphole. The tee of the drop line should be 1-1/2 to 2 feet above the ground. Usually two different lengths of drop lines will meet these requirements; 2-1/2-foot drop lines for use on slopes and 4-foot drop lines for use on level ground.

Lateral Lines

The coils of 5/16-inch I. D. tubing are taken to the starting point of installation in the sugar bush, usually the storage tank at the roadside or at the evaporator house. The laterals are laid out and connected by the second three-man team.

The lead man carries the coil of tubing. With an end held by the other man, the tubing is laid to the first tree tapped. The tubing is gently pulled to obtain the desired length, and untwisted to free it of loops so that it lies flat on the ground. It is then cut from the coil.

If the tubing is not straightened out (uncoiled) the top of each loop of the coil will produce a "high spot" and cause a gas or air lock which will prevent sap from flowing through the tube. The length of tubing between any two trees is made just long enough to be ground supported but without any excess which would result in sags where the tubing passes over an obstruction such as a log or a boulder. Either of the other two men advances to this point to again hold the cut end of the coiled tubing and the lead man advances to tree number two, laying out the tubing as he goes. The second and third men alternate in the following tasks: holding the tubing while it is being laid out; disinfecting the ends of the tubing, tees, and connectors; and connecting the laterals to the tees of the drop lines. Where there are multiple drops (tapholes) on one tree, they are connected with 1-foot length pieces of 5/16-inch I. D. tubing.

The laying of tubing in shaded areas should be avoided as much as possible since any frozen sap in the lateral lines will be slow to thaw and will act as a plug. All connections and drops to laterals should be on the southern side of the tree to favor early thawing of any ice formed in the joints.

After the tubing has been installed, a check must be made of the entire system to ensure that all connections have been properly made. Inspection tours should be repeated throughout the sap flow season to check for leaks and separated joints. This is extremely necessary if the tubing had been installed over deep snow which has melted during the sap season.

Number of Taps per Lateral or per Ground Line

The greater the slope or pitch the larger the number of taps that can be attached to a single lateral. The greater pitch makes the sap in the lateral flow faster, and so a larger volume of sap can be moved. On very steep slopes up to 100 taps can be connected to a single lateral.

On level land as many as 50 taps may be connected to a single 5/16-inch lateral, providing certain basic installation procedures are followed. The tapholes must be at least 6-feet above ground to provide sufficient hydrostatic pressure to cause the sap to flow through the lateral line and also to assure a free space in the drop line of at least 5-inches between the spout and the sap level.

As the slope becomes less, the rate or velocity of sap flow diminishes and the problem of gas or air lock increases. This can be almost entirely eliminated by shortening the drop line so that its lower end, with the tee connector, is at least 2-feet above ground level. This causes a high point in the lateral line at each tree and results in freeing the line of gas or air at each taphole, preventing buildup of gas pockets which would cause a gas lock that prevents sap flow.

Where laterals discharge in a main line, a vent tube must be installed at the junction point and suspended in a vertical position (a) to free the line of gas during sap flows and (b) to permit admission of air to allow the main line to drain at the end of a sap flow period.

Main Lines

The mains are installed with a two-man team. Beginning at a location farthest from the storage tank, and where two lateral lines converge, the team lays the lines in the most direct route to the storage tank. Low places should be avoided as much as possible. The first length of the main should be 1/2-inch I. D. This will be increased in size as the quantity of sap led to it increases.

The volume of sap (number of taps) carried by a 1/2-inch main will depend upon the velocity of the sap flowing through it and is related to the slope of the ground where it is installed. Where two or more of these 1/2-inch mains

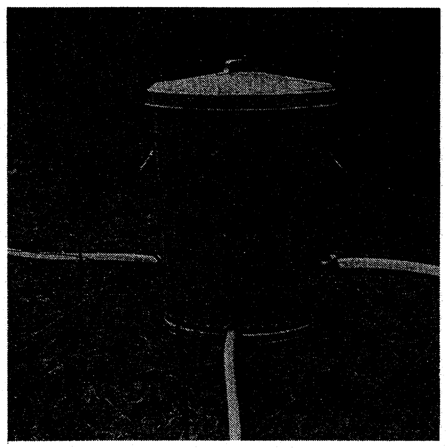

Figure 4. Junction of mainline tank. The 10- to 20- gallon tank permits escape of gas or air entrained in the sap stream and it also acts as a surge tank.

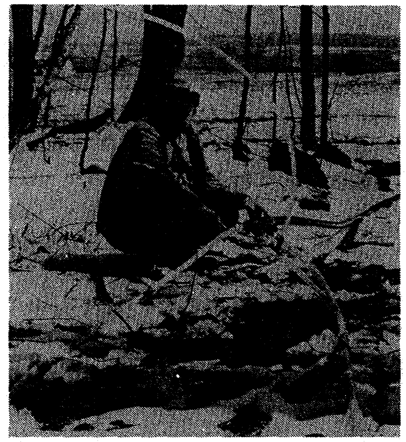

Figure 5. A vent tube at the junction of mainlines.

converge, a larger main of 3/4-inch to 1-inch must be used. The junction is best made with a small tank (Figure 4). This tank serves (a) for venting the line and (b) as a surge tank. Extreme care must be taken to see that the larger main on the downstream side of the junction is sufficiently large to carry away all of the sap being fed into it, especially on days of large sap flows. If a tank is not used, then a simple device that will show whether or not the mains are of sufficient size can be installed. This is an 8- to 10-foot length of 5/16-inch tubing connected at the junction point and suspended in a vertical position. If sap overflows this tube, the downstream main is too small. Figure 5 shows a vent tube at the sunction of two mains. In many sugar bushes 1/2-inch I. D. mains are all that are required. A 3/4-inch I. D. main has the carrying capacity of two 1/2-inch mains and a 1-inch I. D. main has the capacity of four 1/2-inch mains. The mains, while of large diameter, are also subject to stoppage by gas or air locks, especially if the main at any point is completely filled with sap. If there is a high point in the line where it is laid over a log, a vent tube must be installed at the high point. If the main goes through a depression such as a creek bed or small valley, an open-top tank must be installed in the main line a few feet above and on the upstream side of the depression. Sap will freeze in the main line in the depression, therefore the tank should be large enough to hold the sap that flows while the ice in the downstream main is thawing. This tank may therefore need to have a capacity of 300 gallons or more.

A more expensive means that will largely correct improper installation or remove interfering gas or air locks is the installation of a vacuum pump at the downstream end of the main line. These pumps will not correct for ice plugs in the main lines.

TAKE-DOWN OF TUBING

It is essential that the tubing be taken down not later than 1 week after the last run or after the trees begin to bud. To delay will permit growth of microorganisms and make the subsequent cleaning and sanitizing more difficult. During the sap flow season the temperatures are usually cool enough so that the rate of germination of any microorganisms in the tubing will be slower than their death rate caused by the ultraviolet radiations of sunlight through the tubing. But, as the season progresses beyond the budding period, the warmer weather causes the growth rate to greatly exceed the death rate of the organisms and abundant growth takes place. Therefore, taking the tubing down immediately after the end of the season will make the cleaning operation easier.

The process to be followed in taking the tubing down is merely a reversal of that previously described for its installation. Like the installation, it can be a one-man opera-

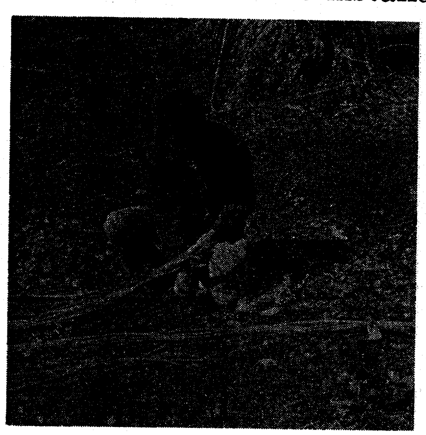

Figure 6. Lateral lines, short connectors, and droplines are disconnected and tied into bundles.

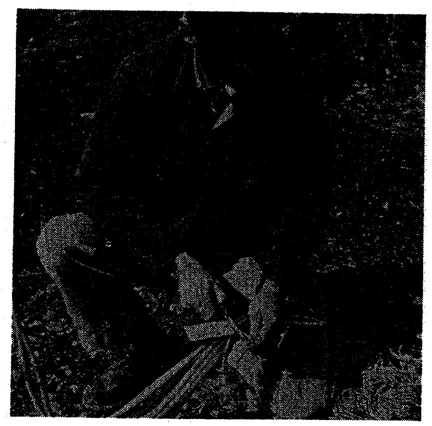

Figure 7. A bundle of lateral tubes is tied and labeled for easy handling.

tion but is more efficiently done by two-man teams.

The lead man of the first team disconnects the drop lines from laterals and the foot-long connectors, which he collects. The second man of the team pulls the spouts from the tree and collects the drop lines assembly. Disconnection of lateral lines, short connectors, and drop lines and tying of tubing bundles is illustrated in Figure 6.

When 25 drop lines have been collected they are tied into bundles, keeping the tee ends flush. Since all the drop lines are alike, no labeling is needed.

The second team collects, bundles, and tags the disconnected lateral lines. The lead man collects the tubing. Beginning at the first tapped tree he picks up the end of the tubing that extends from the main or storage tank and pulls the tube to tree number two. There he picks up the end of the tube extending between trees number one and two and places the end flush with the end of the first tube. Then he pulls the two lengths of tubing to tree number three and repeats the process until a handful of tubing, 20 to 25 pieces, is collected. Smaller lots may be obtained from an isolated section of the sugar bush.

When a handful of the lines has been obtained, it is left at the tree where the last piece was collected. One of the other men ties the flush ends together into a bundle and attaches a label showing the general area of the sugar bush where it was installed. The bundle of tubing is then tied into a 2-foot diameter coil for easy handling. The tying and labeling of a bundle of lateral tubes is shown in Figure 7.

CLEANING AND SANITIZING THE TUBING

This system of installing and dismantling the tubing is not only simple but provides ease in subsequent washing and sanitizing of the tubing.

At the end of the maple season most of the interior of the tubing is either wet or moist with sap. With the warmer weather at that time, temperatures are favorable to microbial growth (yeasts, molds, and bacteria). However, if the sap in the tubing is sterile, due either to excellent sanitary practices or to the sterilizing effect of sunlight, no subsequent growth will occur. Since the latter situation seldom, if ever, occurs, excessive microbial growth usually will take place, especially since the temperatures are higher following the take-down of the tubing. Once growth takes place it becomes increasingly difficult to clean the tubing. Therefore, it cannot be too strongly recommended that the tubing be washed within a few hours, or at best, one or two days, following its take-down. Tubing in which excessive microbial growth has taken place must be cleaned by more elaborate methods such as described in "Cleaning Plastic Equipment Used in Handling Maple Sap" (5).

Equipment

The following equipment is required for washing the tubing:

(a) A tank to hold the hypochlorite solution. This can be a 55-gallon drum or a tank (stock watering) of approximately 200-gallon capacity.

(b) A gear pump which will deliver at least 50 gallons per hour and 10 to 15 pounds' pressure. A bypass arrangement on the pump, as shown in Figure 8, provides flexibility of operation. The pump is attached to the drain valve of the tank and is equipped with a 15-foot length of hose provided with a tapered nozzle. The tank and pump assembly are illustrated in Figure 9. The tapered nozzle is made from several 1-inch lengths of metal (copper) tubing of different diameters soldered together so as to produce a taper from the smallest to the largest tubing size. The outside diameter (O. D.) size of the smallest tubing should be just slightly smaller than the I. D. of the smallest I. D. of the

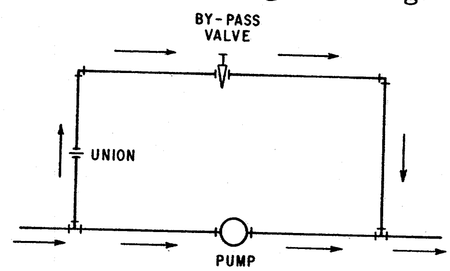

Figure 8. This pump bypass arrangement provides control of discharge volume.

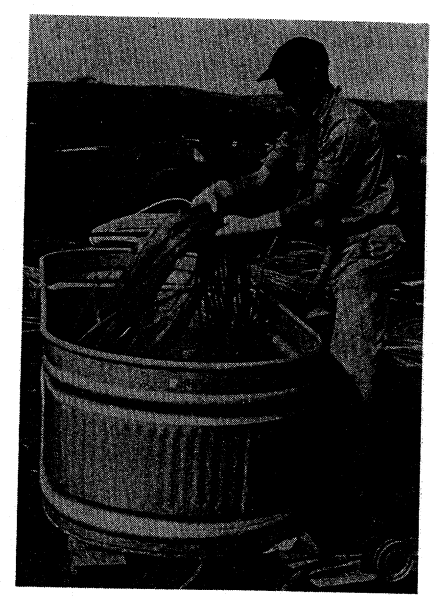

Figure 9. An efficient tank and pump assembly is essential for washing the tubing.

plastic tubing so that it will slip into the tubing easily but snugly.

(c) Wash or sanitizing solution consists of 20 gallons of a commercial bleach, free of detergent, and 180 gallons of water.

(d) Rubber gloves.

CAUTION

To protect the hands against the caustic action of the hypochlorite solution, rubber gloves must be worn during the washing operation.

Washing the Laterals

A coil of the tubing is submerged in the tank of hypochlorite solution. The drain valve connecting the tank and pump is opened, and the pump started. The stream delivered from the hose nozzle is adjusted by means of the pump bypass valve. The bundle of tubing is picked up, and held by the flush ends. The nozzle is inserted into one of the tubes until the tube is completely filled with the wash solution. This operation is illustrated in Figure 10. Complete filling of a tube usually requires less than a minute and is indicated when air bubbles no longer emerge from the discharge end of the tube. As each tube is flushed and filled with hypochlorite solution it is released so that only the unwashed ones are held. When all of the tubes of the bundle have been flushed and filled with cleaning solution, the coil is allowed to sink to the bottom of the tank and another coil of tubing is placed in the tank and the process of flushing and filling each tube of the new coil is repeated. This is continued until the tank is filled with tubing.

Figure 10. Wash solution is pumped through the tubing.

The tubing is soaked for two hours, then each tube is again flushed, beginning with those in the first coil put in the tank. As soon as all of the tubes in a bundle have been

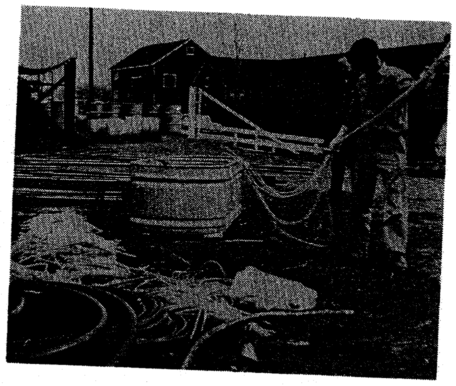

Figure 11. The wash solution drains back into the tank as the tubing is slowly withdrawn.

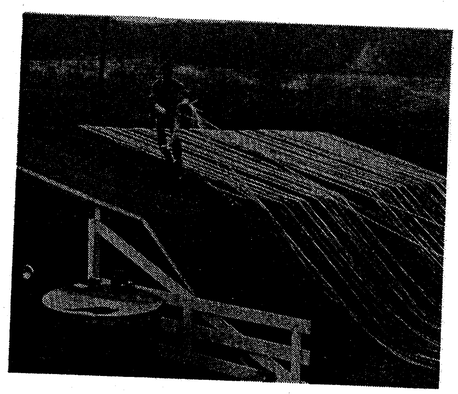

Figure 12. The tubing is drained on ground slope or roof. About 12 miles of tubing are being drained in this photo.

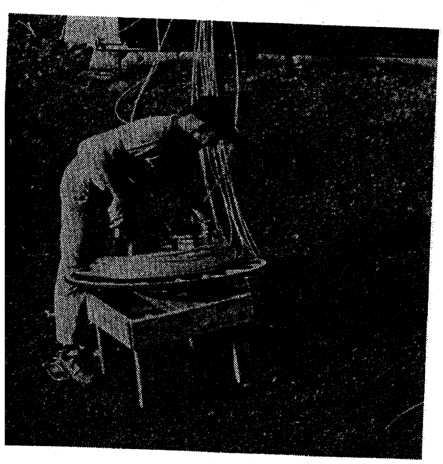

Figure 13. A rack mounted on a wheel is recommended for coiling the bundles of tubing.

washed, the strings holding the bundle in the coil are cut, but not the string holding the flush ends of the bundle. Then, the bundle, held by the flush ends, is pulled slowly from the tank. As the coil unwinds, the solution in the tubes drains back into the tank. This step is shown in Figure 11.

The bundle of tubing is then pulled to a slope or laid over the roof of a building to drain as illustrated in Figure 12. Thus, the hypochlorite solution is drained but not washed out of the tubing.

After 10 to 15 thousand feet of tubing have been washed, the tank is drained and refilled with fresh hypochlorite solution.

After draining, the bundles are taken down and again coiled on a rack mounted on a wheel, which rotates on an axle mounted perpendicular to the ground, as shown in Figure 13.

For storage, several bundles of tubing obtained from the same sugar-bush area may by wound and tied in the same coil for ease of handling and to conserve space. The coils of tubing are then stored in a clean, dark, cool place which is free of rodents. Large metal drums or tanks with 1/4-inch mesh hardware cloth covers make ideal storage containers.

Washing the Drop Lines

Washing of these tubes is very simple. A bundle of drop lines is picked up and held by both ends. The bundle is lowered slowly and perpendicularly, tee end first, into the tank of hypochlorite to displace the air and to completely fill the tubing and fittings (tees, spouts, and vent) with solution, as shown in Figure 14. Without releasing the bundle, it is lifted out of the cleaning solution holding it in a vertical position for a few moments to drain. The ends are then reversed and

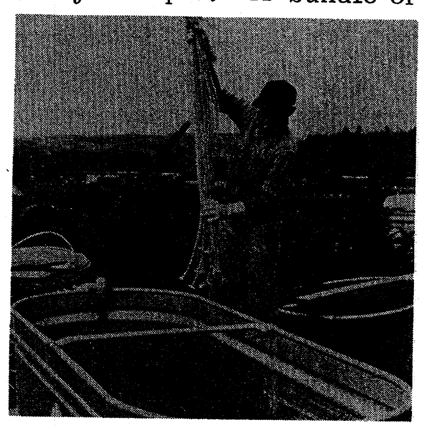

Figure 14. A bundle of droplines is lowered slowly and perpendicularly into the wash solution.

the bundle is again lowered into the solution. The bundle of drop line assemblies after the second filling is left in the tank to soak for 2 hours. After the soaking period they are again flushed two or three times, holding them in a vertical position for a few seconds to permit the bulk of the hypochlorite solution to drain back into the tank. They are then hung by the cord ties at spout end to drain. This draining step is illustrated in Figure 15. After draining, the bundles of drop lines are taken down and stored in the same manner as the lateral lines.

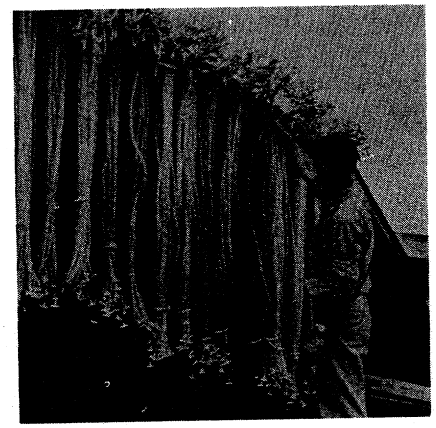

Figure 15. A bundle of droplines is hung by the cord tied at the spout end for draining.

Washing the Main Lines

The coils of main lines are washed, drained, and stored in exactly the same manner as the lateral lines. A larger nozzle is used to fill and flush the tubing with the hypochlorite solution.

REINSTALLING THE TUBING IN THE SUGAR BUSH

This operation, like the others, proves the merit of this system. The reinstalling is carried out in practically the same manner as that of the initial installation.

Layout of Main Lines

The cut, clean, large-diameter tubes are laid out in the sugar bush in the same manner as that followed for the initial installation.

Tapping and Installing Drop Lines

Again, two three-man teams are used. The first team drills and disinfects the tapholes and installs the drop line assemblies that have been kept intact in convenient bundles.

Installation and Connection of Lateral Lines

Likewise, the second team lays out and connects the lateral and main lines. The coiled bundles of lines are sorted and the one selected according to their labels for the given sugar bush area where the work is to begin. The coil is cut apart and the lead man of the team, holding a bundle by the tied flush ends, drags it to the starting point following the blazed marks of the preceding year. Since each bundle contains different lengths of tubing, the second man, who is at the starting point at that time, selects the tube that matches the distance from the starting point to the first tree and by a slight pull disengages it from the bundle. Both men now advance, the lead man proceeds to the second tree and the second man to the first tree tapped where he again selects a length of tubing that matches the distance between the two trees. He connects the lateral lines with the tees of the drop lines. This procedure is repeated again and again until the entire bush has been reassembled with the lateral and drop lines.

ECONOMICS

The total cost of this type of installation is usually less than \$1.50 per taphole.

The yields of sap through the use of tubing are high. Since there is no back pressure to prevent flow, every drop of sap is collected. No losses occur through spillage or overflow of buckets. It is not uncommon for the tubing to be paid for the first year it is in use. For example, one farmer who sold his sap to a central evaporator plant received an average of \$1.90 for the sap produced from each taphole.

Because of the great savings in labor, other farmers have said they would continue to use tubing to collect and transport sap from the sugar bush even in years when sap flow was only half of a normal crop.

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